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AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

THE INTEGRATION OF UNMANNED AERIAL VEHICLES INTO THE FUNCTION OF COUNTERAIR

by

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Preface

"The objectives of the counterair function are to facilitate friendly operations against the enemy and protect friendly forces and vital assets through control of the air."[1] The first course of action that US forces undertake during military campaigns is to control the air through some level of air superiority. Without air superiority, all other military functions, be they on, under, or above the surface of the earth will have a significantly more difficult time accomplishing nationally directed objectives. Air superiority is the key first step to all successful military operations.

Similar to air superiority, achieving information superiority is also essential to winning any future military operation. Every aspect of the application of military force is reliant upon quickly acquiring accurate information and disseminating that information to the correct war fighter in the most efficient and timely manner. Unmanned Aerial Vehicles (UAVs) are an integral aspect of information superiority. In past military operations, UAVs were instrumental in the intelligence, surveillance, and reconnaissance (ISR) function. During operations in Kosovo, UAVs began to branch off from their traditional role of ISR to play a more active role in combat operations. As UAV technology advances and UAVs become smaller, lighter, and less expensive, more opportunities will arise in which UAVs may either augment or even replace manned aircraft in the accomplishment of assigned missions.

As an F-15C pilot with over ten years experience in counterair, I envision a significant role for UAVs in the function of counterair. Likewise, I also see that the counterair community may reject or feel threatened by the integration of UAVs into the function of counterair. My goal with this research paper is to educate both the UAV and counterair communities as to the possibility of UAVs augmenting the function of counterair, not replacing current counterair weapon systems. I believe that the miniaturization of technology has advanced to the point where UAVs can effectively assist current and future counterair weapon systems to better accomplish the function. Conversely, I do not believe that technology has advanced to the point where UAVs could replace manned air superiority aircraft. It is my belief that a UAV operator at a remote location could not effectively or accurately assess every necessary aspect of a combat situation to make the timely decisions concerning a visual aerial fight. I therefore will refrain from discussing unmanned combat aerial vehicles (UCAVs).

This paper would not be possible without the help of several individuals. I would like to thank those who have greatly contributed to the research of this paper. First of all, I would to thank my research advisor, Colonel Stephen C. German, the Vice Commandant at Air Command and Staff College. His insight, time, and patience were invaluable to me in this research project. I would also like to thank Mr. Michael Little in the Sensor Directorate at the Air Force Research Laboratory, Mr. Keenon Cooksey and Lt Adam Wehner at the US Air Force Global Hawk System Program Office, Lt Colonels Mark O'Hair, Thomas Bailey, and Paul Schroeder at the US Air Force UAV Battle Lab, Major George Moretti at the US Army Ballistic Missile Defense Office, and Commander Sean Buck and Lt Colonel Jesse Hoag at the Reconnaissance Operations Division, Joint Staff. Finally, I would like to thank my patient wife Kathryn, for all her assistance.

Notes

[1] Headquarters Air Force Doctrine Center, *Air Force Doctrine Document 2-1.1* (Maxwell AFB, AL, 6 May 1998), 1

Abstract

With the recent draw down of the US military after the end of the Cold War, the US Department of Defense (DoD) is placing considerable emphasis on employing a lighter, leaner, and more lethal military force to accomplish the strategic objectives mandated by political leadership. As a force enabler for military forces, Unmanned Aerial Vehicles (UAVs) recently demonstrated their potential during NATO military operations in Kosovo. Their activities weren't limited to merely gathering enemy intelligence. As a result of advancements in UAVs capabilities, UAVs expanded their operations by directly assisting in combat missions. The resulting logical question that evolved out of the Kosovo operations is, can UAVs be more actively integrated into other military functions to enhance mission accomplishment? More specifically, can UAVs be incorporated into the function of gaining and maintaining control of the air for US forces?

To completely answer this question, this research paper will first analyze the current background of UAVs as seen in recent military operations. Secondly, the function of counterair will be examined to identify the deficiencies US forces have in obtaining control of the air. Third, the present and future capabilities that UAVs can bring to the fight will be identified. Fourth, a detailed examination of which UAVs payloads can be incorporated into the function of counterair will be accomplished. Fifth, this paper will show that UAVs can be effectively integrated to enhance US military weapons systems accomplishment of the function of

counterair. Finally, this author will briefly discuss one possible plan to integrate UAVs in the function of counterair to overcome the noted deficiencies.

Part 1

Introduction

Air control can be established by superiority in numbers, by better employment, by better equipment, or by a combination of these factors.

—General Carl "Tooey" Spaatz

Background

Many military strategists and theorists have concluded, based on recent history, the nature of future wars will be limited to regional and intrastate conflicts. Large interstate wars such as World Wars One and Two and the Persian Gulf War are not likely to be the wars of the future. Operations such as ALLIED FORCE and DESERT FOX are likely to be more representative of the types of conflict the US and its allies will face in the future.

When the United States participates in wars where our vital interests are not at stake, the US public has little tolerance in seeing its sons and daughters killed while intervening in perceivably less important foreign operations. Likewise, the US does not wish to lose its valuable military resources unnecessarily. As a result of the DoD draw down, the military is forced to implement national security strategies worldwide with a reduced number of assets. This fact is a key point when one comprehends the complexities involved with the US's strategy of being prepared to fight two, nearly simultaneous major regional contingencies (MRC). In order to meet this requirement, it is necessary to either hold forces in reserve or be prepared to "swing" forces from one conflict to another. In either case, the US must maximize the fighting capability of every weapon systems employed to ensure quick success. More importantly, the synergistic application of systems in a Joint arena will be critical to quick and decisive victory.

Recent operations have witnessed the employment of US counterair weapon systems struggling to control the air while being faced with little enemy air-to-air resistance. When air-to-air threats were engaged, the reports of these operations illustrated how, many times, US counterair assets had difficulty finding the airborne enemy targets and identifying them early enough to engage those targets in a timely manner. Moreover, friendly counterair assets were forced to stay above ten thousand feet to avoid small arms fire and other surface-to-air threats, which friendly assets lacked the capability to totally jam, suppress, or eliminate.[1] Counterair weapon systems were dealing with radar coverage too inadequate to build the air picture, inadequate capabilities to identify targets, an inadequate ability to wage electronic combat, and inadequate protection from enemy air defenses.

These recent operations have also seen an increase in the employment of UAVs for intelligence, surveillance, and reconnaissance (ISR) missions with great success. Technology has advanced to allow for the miniaturization of electronics, which have provided the military the opportunity to expand and vary the payloads in UAVs. During Operation DESERT STORM, UAVs were widely employed. The UAV Pioneer flew over 300 combat missions.[2] These UAVs greatly improved the coalition's success and impressed military leaders around the world. "This performance was characterized by a degree of technological sophistication, married to doctrinal and operational concepts, that resulted in a new vision of what high-intensity, fast-paced operations of the future might entail."[3]

In 1999, during Operation ALLIED FORCE in Kosovo, additional operational constraints, requiring UAVs to be utilized to a greater extent were placed on military planners. Commanders had to follow two absolute rules while planning air strikes: "ensure they had 'zero casualties' and 'no collateral damage.'"[4] Four North Atlantic Treaty Organization (NATO) countries operated UAVs against Kosovar Albanian troops. The United Kingdom, France, Germany, and the US relied heavily upon UAVs for their ISR missions. UAVs operated in a classical role to achieve great success, but not without a price. "In all, these countries admitted they had lost about 20 UAVs, both to technical failures and to enemy action."[5]

During the later part of Operation ALLIED FORCE, UAVs began integrating into an alternative function. Military commanders had begun to comprehend alternative employment possibilities for UAVs and then capitalized on that flexible platform to positively affect the mission of interdiction. UAVs were retrofitted to carry a laser in order to designate targets on the ground. In this way, UAVs were able to locate and designate targets so that manned fighters could more easily deliver their munitions.[6] UAVs began performing functions previously preformed by manned aircraft thus reducing the number of manned missions required to enter hostile airspace. By integrating UAVs into the mission of interdiction, military planners had opened the door to future alternative applications of UAV employment.

Statement of the Research Question

As stated in Joint Pub 1, "the ability to project and sustain the entire range of military power over vast distances is a basic requirement for the Armed Forces of the United States and contributes, day in and day out, to the maintenance of stability and deterrence worldwide."[7] Technological improvements in sensors and mobility will greatly support this basic requirement by contributing to the war fighters' ability to wage war. Technology may be the key to success in the US military's quest to dominate the battlefield and the war of information while ensuring the least amount of allied and civilian casualties. History has demonstrated the necessity of air control as a premiere objective in battle. Therefore, if the US is to succeed on the surface or in the air, it must first achieve air superiority. Air superiority allows for the freedom of action of friendly forces while denying any attack from enemy air forces.

Unmanned Aerial Vehicles offer the US great advantages in information gained through their platform sensors while allowing improved mobility over the battlefield. As technology rapidly advances, will UAVs possess the correct capabilities or payloads to assist counterair assets in their function? If so, can UAVs be effectively and efficiently integrated into the function of counterair? If the answer is yes, then the future of counterair may be greatly aided by the integration of highly mobile and technologically advanced UAVs into this function thus ensuring US dominance of the air in any given scenario.

Intended Audience

This research paper is primarily intended to provide information to those personnel within the US Department of Defense (DoD) who are responsible for determining the proper size and capabilities of counterair and UAV assets in present and future force structure studies. This paper is also intended to provide those decision-makers on major commands and headquarters staffs with information and concepts necessary to make effective and more informed decisions. Additionally, this paper is intended to furnish a general understanding of the potential benefits and limitations of UAVs and their contribution to the function of counterair to all DoD personnel.

Limitations of the Study

The primary limitation of this study is the classification of this research project—unclassified. Although the classification is a limitation, it is not significant. The actual technical details of intelligence, surveillance, reconnaissance, and low-observable capabilities of some UAVs are classified, but the general systems themselves are unclassified. Additionally, this study is limited by the time available to conduct the research and by the desired length of the research project. To curtail the scope of this project, only general capabilities of systems are analyzed. Finally, an arbitrary date, 10 January 2000, was chosen as a cutoff date for new information. Changes to programs and systems after this date are not reflected in this paper.

Notes

[1] Lestapis, Jacques de, "Drones, UAVs Widely Used in Kosovo Operation" (07/07/1999), n.p.; on-line, Internet, July 1999, available at http://www.defense-aerospace.com

[2] Rivers, Brendan P., "UAVs: 100 Eyes in the Sky," n.p.; on-line, Internet, June 1999, available at http//www.jedonline.com

[3] Robertson, Scot, "The Development of Royal Air Force Strategic Bombing Doctrine between the Wars: A Revolution in Military Affairs?" *Airpower Journal*, Vol. XII, No. 1, Spring 1998

[4] Lestapis, Jacques de, "Drones, UAVs Widely Used in Kosovo Operation" (07/07/1999), n.p.; on-line, Internet, July 1999, available at http://www.defense-aerospace.com

[5] Ibid

[6] Ibid

[7] Joint Pub 1, *Joint Warfare of the Armed Forces of the United States* (Washington D.C.: US Government Printing Office, 10 January 1995), I-1

Part 2

Counterair Limitations

The future battle on the ground will be preceded by battle in the air. This will determine which of the contestants has to suffer operational and tactical disadvantages and be forced throughout the battle into adopting compromise solutions.

—German General Erwin Rommel

Operation DESERT STORM

On 17 January 1991, the world witnessed the largest employment of air power since WW II. The US led coalition air forces dominated the Iraqi military. USAF F-15C, USN F-14A/D, and USN and USMC F/A-18 aircraft primarily accomplished the control of the air with minimal support by Saudi F-15C and French Mirage F-1 aircraft. Over 13,000 coalition aircraft flew counterair missions, averaging 340 sorties daily, thus ensuring air superiority. The thirty-three fixed-winged air-to-air kills achieved by coalition forces ensured freedom of action for all coalition forces.[1]

The Gulf War was the first conflict in history in which half of the aerial kills were a result of beyond-visual-range (BVR) shots, showcasing the level of technological development achieved by the US.[2] There were three contributing factors to this success. The first factor was the level of dominance over the Iraqi Air Force by coalition air forces. Second, the success was also due to the level of sophistication of the US weapon systems involved. Finally, the deconfliction measures employed to prevent fratricide and the rules of engagement (ROE) for engaging hostile aircraft were extremely well choreographed and greatly contributed to coalition success. Coalition fighters worked in conjunction with E-3 AWACS (Airborne Warning and Control System) to find, identify and then engage enemy aircraft. In spite of the high success rate for the coalition air forces, there were significant challenges in achieving and maintaining control of the air. These challenges primarily included finding and identifying airborne targets, electronic warfare, and the suppression of enemy air defenses (SEAD).

Figure 1. F-15C Eagle

Operation ALLIED FORCE

In 1999, during Operation ALLIED FORCE, nineteen NATO countries flew over 34,000 sorties in 78 days. The air operations were conducted much like the air campaign of 1991 with the US dominating the enemy.[3] Although the total number of air assets in theater was less during ALLIED FORCE, the same general types of assets were available to accomplish the function as in DESERT STORM. Counterair assets engaged relatively few airborne targets while encountering the identical challenges that counterair assets encountered during DESERT

STORM. This suggests the weapon systems employed to accomplish the function of counterair simply did not possess the capabilities to adequately perform all their assigned functions with the freedom their operators preferred. By analyzing the complex missions of finding and identifying airborne targets, electronic warfare, and SEAD, the difficulties of controlling the air may be better understood.

Limitations of Finding and Identifying Airborne Targets

Before an airborne target can be identified as hostile and engaged by counterair assets, it must first be located and tracked. The E-3A AWACS is the US and NATO's primary system designed to accomplish both. Although AWACS possesses state-of-the-art technology for finding and identifying targets, there are certain limitations that also exist. The first is the placement of its operating orbit. E-3As are considered "high value assets" due to their great capability, relatively few numbers, and high price tag. As such, AWACS are placed sufficiently far from any potential hostilities to avoid possible engagement. This aft placement for security reasons typically places some or much of the enemy airspace beyond the surveillance range of the AWACS. Additionally, if the terrain is hilly or mountainous, radar "blind spots" may exist.

Figure 2. E-3A AWACS

Air superiority fighters have limitations similar to E-3As for detecting enemy aircraft. Specifically, fighter aircraft have radar detection range and blind-spot limitations that can delay the running of an intercept. In addition, political limitations may exist as to where the fighters may place their combat air patrol (CAP) orbits, which further reduces the range in which they can detect enemy aircraft.

Once an aircraft is located, limitations still exist in the various weapon systems' ability to identify airborne targets as either friendly or hostile. AWACS and some fighter aircraft possess the capability to interrogate and identify both friendly and hostile aircraft through both positive identification and procedural control. AWACS also receives classified inputs, which aid in the identification of enemy aircraft. Even with this level of sophisticated identification capabilities, there still are limitations in the E-3A's ability to reliably and consistently produce the desired 100% accuracy required to prevent fratricide. Many of the enemy fighters' electronic signatures are very similar to the US fighters, which creates ambiguities in the identification process. This ambiguity can delay or prevent the engagement of enemy aircraft in the BVR arena where the US is so dominate. Additionally, if an aircraft is actively employing electronic warfare systems, then many of the identification systems are degraded or unusable further compounding the identification problem.

Limitations in Electronic Warfare

During Operation DESERT STORM, the USAF EF-111 Raven and the US Navy EA-6B Prowler aircraft were the primary weapon systems that supported air operations through electronic attack (EA). "Electronic warfare aircraft played a central role in the neutralization of the Iraqi air defense system… Unavailability of electronic warfare aircraft, in fact, was a reason to abort an attack mission."[4] Both the Raven and the Prowler were instrumental in electronically attacking or jamming the enemy's radar, thus denying the enemy the ability to detect coalition aircraft. In addition to the Raven and Prowler, fighter aircraft can conduct limited EA functions. Fighters may have an internal jamming system or have the ability to carry an external self-protection EA pod. In either case, fighters possess only a limited EA capability.

After DESERT STORM, the military was required to cut its forces. This resulted in the elimination of the EF-111. The Navy's EA-6B was the only dedicated EA weapon system remaining in the US inventory. Unfortunately, the military discovered, all too late, that the various operations around the world over-tasked the EA-6B leaving less than the required number of dedicated EA assets for multiple operations and contingencies.

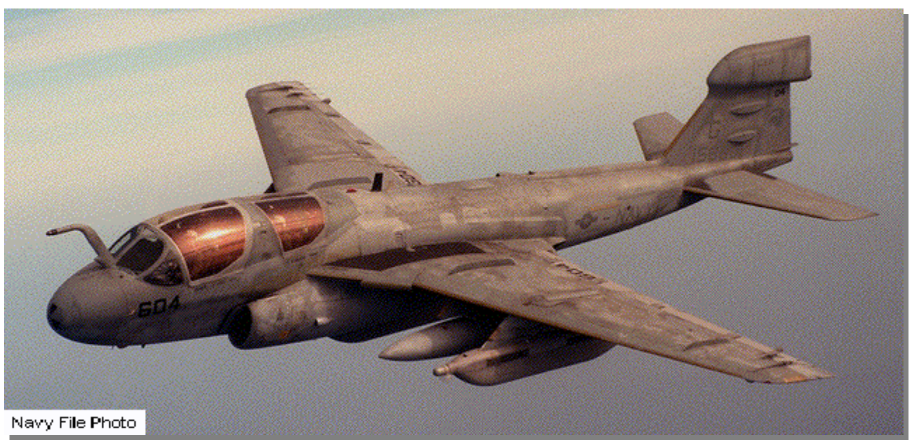

Figure 3. EA-6B Prowler

Mission requirements may further limit fighter aircraft's EA capability. Mission constraints may dictate the removal of their EA pod for the addition of an external fuel tank or added munitions. If the fighter has a great distance to travel or must remain on station for a long period of time, then an external fuel tank must be added. Likewise, the EA pod may be removed to add a sufficient number of munitions in order to achieve the desired destruction of an intended target. The net effect of reducing the EA capability is to reduce the overall likelihood of a mission's chance to succeed without the loss of friendly casualties due to enemy air defense.

Limitations in the Suppression of Enemy Air Defense (SEAD)

Control of the air not only involves attriting an enemy's air force, but also suppressing its air defense force. If the US is to be successful in future campaigns, then the enemy's air defense must be either destroyed or negated for the period of time US forces will fly in enemy airspace. One of the major lessons learned from DESERT STORM was how difficult it was to provide adequate SEAD for strike missions due to the limited SEAD assets available.[5] Following the Gulf War, as part of the military draw down, the USAF's primary SEAD system, the F-4G "Wild Weasel" was retired from the inventory. The F-16CJ and the F/A-18, with significantly limited SEAD capabilities and fewer numbers, were introduced as the replacements for the F-4G. Presently, the F-16CJ, F/A-18, and EA-6B are the only SEAD assets in the US arsenal. Given the limited numbers of both the F-16CJ and F/A-18 and the high demand for the EA-6B in the EA role, there is an inadequate number of SEAD assets currently available to handle the tasking of more than one MRC.

Conclusions

On the surface, it appears that the United States military has enjoyed great air combat success in the last decade. In reality, this success was achieved against adversaries that launched very little air resistance. If a future war pits the US against an adversary with significant counterair assets and capabilities (e.g. China, India, or Russia), then the US cannot expect the same success it has experienced in the past. Unless additional systems are incorporated into the US arsenal that augment detection and identification of airborne targets, electronic warfare, and SEAD, then the US may witness a decidedly prolonged war that wears on military resources as well as US public support. The current surveillance, electronic warfare, and SEAD systems' lack of capability, coverage, and availability is a major concern for our nation's combat air forces.

Notes

[1] Keany, Thomas A. and Cohen, Eliot A. *Gulf War Air Power Survey Summary Report* (Washington D.C., US Government Printing Office, 1993), 56

[2] Ibid, 60

[3] Works, Benjamin C. "Kosovo Lessons Learned", revised 27 July 1999, n.p.; on-line, Internet, 3 January 2000 available from SIRUS: The Strategic Issues Research Institute at http://www.siri-us.com

[4] Keany, Thomas A. and Cohen, Eliot A. *Gulf War Air Power Survey Summary Report* (Washington D.C., US Government Printing Office, 1993), 195

[5] Winnefeld, James A. and Johnson, Dana J, *Joint Air Operations – Pursuit of Unity in Command and Control, 1942-1991* (Annapolis, Maryland, Navy Institute Press, 1993), 123

Part 3

Unmanned Aerial Vehicles

In war the victorious strategist seeks battle after the victory has been won, whereas he who is destined to defeat first fights and afterwards looks to victory.

—Sun Tzu

Background

The United States military has used UAVs since the 1950's when it used the Lightning Bug reconnaissance drone and a converted Firebee target drone as reconnaissance platforms.[1] Since then, the US and several other countries have employed UAVs in a variety of intelligence, surveillance, and reconnaissance functions. UAVs such as Aquila, Hunter, Predator, Pioneer, Phoenix, Crecerelles, and Mirach 26, just to name a few, have flown countless hours during numerous military operations all over the globe with great success.[2] During Operation DESERT STORM, even the Iraqi soldiers witnessed the effectiveness of UAVs. "According to Joe Thomas, UAV Program Manager for AAI [Corp], 'When they [the Iraqi soldiers] saw the air vehicle, shortly thereafter things started blowing up' leading one Iraqi unit to surrender after merely observing a Pioneer flying overhead."[3]

UAVs currently make up only one percent ($600 million) of the annual DoD acquisition budget, but possess unlimited potential for future military operations. Many military strategists contend that war is becoming extremely information based and that UAVs will play a key role in all future military operations.[4] UAVs will provide this information at or near real-time without placing humans at risk. UAVs appear in various sizes and accomplish a multitude of functions depending on the "black box" or payload(s) placed within them. Since each service has slightly different needs, DoD plans on fielding a variety of UAVs. Table 1 depicts the major UAV programs that the US has undertaken.

Table 1 Major UAV Programs

Program	Period	Description	Status
Lightning Bug	1964-1979	Reconnaissance drone first used by USAF during the Vietnam War	Retired
Aquila	1979-1987	Tactical UAV for Army commanders	Cancelled
Amber	1984-1990	Classified endurance UAV	Cancelled
Pioneer	1986-Present	UAV originally acquired to assess battle damage by naval gunfire	Deployed
Medium Range	1987-1993	Tactical UAV for Air Force and Navy	Cancelled
Gnat-750	1988-Present	Long-endurance UAV developed with CIA funding; exported commercially	Used for training and intell missions
Hunter	1988-1996	Joint tactical UAV	Canceled after LRIP
Predator	1994-Present	Long-endurance UAV for theater commanders; based on Gnat-750	Deployed
Darkstar	1994-1999	Stealthy endurance UAV for high-threat	Cancelled
Global Hawk	1994-Present	High-altitude, long-range endurance UAV	In development
Outrider	1996-Present	Joint tactical UAV	In development

SOURCE: Congressional Budget Office[5]

NOTE: LRIP = low-rate initial production; CIA = Central Intelligence Agency

UAV Categories

Unmanned Aerial Vehicles can be broken down into several categories depending on their mission, endurance, altitude flown, or payload capacity. However, they are most often categorized as either tactical or strategic. Tactical UAVs are vehicles that are categorized as having missions that are specific to a local commander. Additionally, tactical UAVs have shorter mission duration and fly at lower altitudes.[6] UAVs such as Pioneer and Outrider fall into this category because local commanders may tactically control them for specific ISR missions. Strategic UAVs are vehicles having missions that possess either theater or national significance and typically are flown at medium to high altitudes with greater endurance.[7] UAVs such as Predator and Global Hawk lie within this category.

Figure 4. Tactical UAV

The physical characteristics of tactical and strategic UAVs can vary greatly. Today, UAVs vary in size from less than six inches such as the prototype Black Widow micro air vehicle[8] to over 116 feet in wingspan such as the Global Hawk.[9] Tactical UAVs can stay airborne only for a couple of hours, while strategic UAVs can remain airborne for over forty hours. UAV payload capacity may vary in weight from a few ounces for micro air vehicles to over 2,000 pounds for Global Hawk. Tactical UAVs typically fly at altitudes below 20,000 feet, while strategic UAVs are capable of flight at altitudes as high as 65,000 feet. Depending on the engine power and UAV wing dynamics, UAVs as listed can fly at varying speeds up to 345 miles per hour.[10]

UAV Payloads

Unmanned Aerial Vehicle missions are contingent on the payloads that they can carry. Inherent in all UAVs is a propulsion system (engine), a power source (either from the engine or a generator), flight control system, navigation system, communication capability to the UAV control unit, and a payload. All of these basic functional elements of the UAV add to its overall weight. Similar to the air vehicles, payloads vary in size, weight, and power requirements. Fortunately, with the advancement of technology and miniaturization of that technology, both UAVs and their payloads have become smaller, less expensive, and more functional. Because of these same advancements, the UAV community has witnessed an increase in the variety of payloads that have been developed. The payloads can be divided into categories related to UAV missions.

IMINT

The imagery intelligence (IMINT) category payload is a receive-only payload that incorporates photography, infrared (IR) sensors, lasers, electro-optical (EO) devices, multi-spectral and radar sensors.[11] This is by far the largest category of payloads currently in operation. Past UAV operations have used one or more of these sensors to gather information on the enemy ground order of battle, find and locate particular targets, and even laser designate those targets for other weapon systems. Military commanders have greatly relied on IMINT gathering UAVs to gain valuable, time-sensitive data in order to wage a war at a pace the enemy cannot match.

SIGINT

The signals intelligence (SIGINT) category payload passively gathers intelligence from the interception and exploitation of enemy electromagnetic transmissions, which include communications, electronic, and foreign instrumentation intelligence.[12] This particular class of payload senses the enemy's emissions and then pinpoints its location and identification. Both SIGINT and IMINT payloads help the war-fighter decide which target(s) must be attacked. Major General Kenneth Israel (USAF, Retired), former head of the Defense Airborne

Reconnaissance Office (DARO) “referred to this concept as ‘interdisciplinary cuing,’ stating that this was presently one of the DARO’s major thrusts. For example, SIGINT can cue a number of the other payloads such as EO/IR systems…”[13]

MASINT

Measurement and signatures intelligence (MASINT) payloads can measure specific parameters such as the demonstrated range of a missile or they can gather the distinct signature characteristics of an object.[14] These payloads can detect and track missiles such as the SCUD missile used by Iraq. They can also detect and track afterburning aircraft, acoustic signatures of enemy ships and submarines, detect underground objects, and accomplish environmental sensing to detect anomalies, which may be man-made.

OTHER

The final category of payload can be defined as dynamic. This catchall class of payload is designed to engage the enemy. One example of this payload includes radar-warning receivers, which inform the UAV (or its operator) that the UAV is being targeted by enemy air defenses. Other examples of dynamic payloads include electronic attack, communications jamming, and psychological warfare systems. Recent technological advances may add to this category and include SEAD systems or bomb carrying UAVs. This has forced some military strategists to postulate a future category—unmanned combat aerial vehicles (UCAVs).

UAV Limitations

Unmanned Aerial Vehicles have advanced dramatically in the last decade and will continue to do so for the foreseeable future. The small size, low speed, and relatively high altitudes provide some tactical UAVs with inherent low-observable characteristics. Even with the current level of technical advancement, combat survivability remains the most significant limitation to UAV employment. While some tactical UAVs can loiter at slow enough speeds to gate them out of many pulse-Doppler radars, they also operate at low altitudes making them vulnerable to enemy small arms fire. Conversely, strategic UAVs operate well above any enemy small arms fire, but fly at speeds observable by radar making them susceptible to enemy air defenses.[15] Strategic UAVs fly at high enough altitudes to negate any threat of IR surface-to-air missiles (SAM), but still operate within the envelope of modern radar-guided SAMs.

The financial aspect of procuring, deploying, and employing UAVs is another limiting factor. Again, advances in technology have made UAVs more affordable, but these same advances have allowed other more expensive payloads to be developed. This financial dilemma can directly affect the employment opportunities in combat. The more expensive the UAV, the less likely DoD will use it in extremely high-threat areas. Although UAVs may have higher attrition rates than manned aircraft, they are not designed to be expendable.[16] For this reason, self-protection suites are being incorporated into the larger, strategic UAVs.

The lack of capability to carry multiple payloads is another limitation. Most UAVs can only carry one payload. In order to fully integrate into the military's functions, UAVs should be able carry more than one payload so as to support multiple functions (ISR, counterair and counterland) simultaneously. It is easier to sell Congress on the idea of procuring a UAV that can support multiple DoD functions. Both UAV development and technological miniaturization must continue to ensure UAVs with the right payloads capability are fielded.

Figure 5. Global Hawk

The final limitation for UAV employment concerns the bandwidth communication availability for UAVs. UAVs are controlled by datalink from a control set. These control sets use UHF, UHF-SATCOM (satellite communications), C-Band, Ku-Wideband, and X-Band SATCOM frequencies. Tactical UAVs typically use UHF radio links that do not compete with SATCOM bandwidths. For tactical UAVs, a limitation exists in the fact that the range of the UAV is constrained to remain within the line-of-sight (LOS) of the control set. A UAV cannot be controlled beyond the LOS of a UHF radio link. SATCOM eliminates this problem, but the bandwidths available for SATCOM are not always available in all theaters. For strategic UAVs, the only means of communication is through satellite communications. If the SATCOM bandwidth is not available, then the strategic UAV cannot fly in that theater. Fixes for the lack of bandwidth availability problem are costly and remain an obstacle that military planners must contend with.

Conclusions

The 1990's witnessed great strides in technology, which have benefited the UAV community. Operations in Southwest Asia and the Balkans saw expanding uses of UAVs and have proven that UAVs are increasingly important to military operations. In a joint statement in the Kosovo after action review to the Senate Armed Services Committee, Secretary of Defense, William S, Cohen and Chairman of the Joint Chiefs of Staff, General Henry H. Shelton stated “the Army Hunter, Navy Pioneer, and Air Force Predator reflect the state of the art in ground control and mission planning capabilities, airworthiness, and mission payloads.”[17] UAVs were critical to the successes of those wars at a pace that the enemy could not match. UAVs also accomplished missions that freed up critical human resources for more important missions while reducing the exposure of aircrews to hostile enemy ground fire.

Although limitations remain for the employment of UAVs in regional theaters, UAVs provide vital intelligence for gaining and maintaining information superiority. UAVs have also proven capable of integrating into combat missions by providing a synergistic application of combat power while reducing the risks to aircrew members. The function of counterair may also benefit from UAV integration if the proper payloads are married to appropriate aerial vehicles thus aiding current counterair weapon systems in gaining and maintaining air superiority. Achieving air and information superiority will permit military commanders to attain strategic goals necessary in accomplishing national objectives.

Notes

[1] US Secretary of the Air Force Public Affairs, “SAF/PA 96-1204 UAV Technologies and Combat Operations,” n.p.; on-line, Internet, 6 Dec 1996, available at http//web.fie.com/htdoc/fed/afr/sab/ant/text/any/afrtech.htm

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Part 4

Integrating UAVs

Improved mission planning, improved processes for interaction between UAV operators and manned aircraft, frequent and realistic training opportunities, and equipment upgrades for individual UAVs all would benefit future force effectiveness.

—William S. Cohen
US Secretary of Defense[1]

The successful integration of Unmanned Aerial Vehicles into the function of counterair is dependant upon successfully acquiring the correct platforms along with the proper payloads and then employing those UAVs with the economy of force so as to provide a synergistic application of information and air superiority. UAV capabilities must provide time-sensitive intelligence to augment current ISR systems. In the age of a downsizing military and diminishing defense budgets, the key to success will lay in UAVs capable of performing multiple missions while overcoming present counterair limitations. Finally, the apportionment and control of UAVs must be worked out at the Joint Staff level after the payloads have been married to the UAVs so as to have the desired effect. The integration of UAVs in combat operations can only occur after the UAVs have been integrated, evaluated, and updated to meet counterair needs in a training environment.

Correct Payloads

The marrying of the correct UAV capabilities necessary to nullify the limitations of counterair weapon systems can currently be accomplished with industry technology. The IMINT, SIGINT, and MASINT capabilities mentioned earlier currently exist in various levels of development today. The question remains: which payloads would be best suited to overcome the limitations of current counterair weapon systems (locating and identifying airborne targets, electronic attack, and the suppression of enemy air defense)?

Locating and Identifying Airborne Targets

Several sensors are available to assist fighters and E-3As in finding, tracking, and identifying enemy airborne targets. Sensor capabilities include TV camera, EO, IR, synthetic aperture radar (SAR), electronic gathering intelligence (ELINT) systems, and other classified capabilities. The sensors range greatly in price, size, and capability. The correct combination is being debated at several levels of military planning and acquisition staffs. Before the decision of which sensor to use is made, the end game operator (e.g. counterair weapon systems operators) must be integrated into the acquisition decision-making process. That process must also take into account both current and future sensor capabilities.

One current sensor developed by Northrop Grumman holds tremendous promise in the SIGINT payload field. The "Tactical Radar Receiver (TRR)" has the capability to accomplish SIGINT, precision location, and identification of radar emitters.[2] When loaded into a UAV and integrated into the air picture, this system could aid in locating and identifying airborne targets. With a system such as TRR, a UAV could fly into enemy airspace ahead of counterair weapon systems, then loiter and provide valuable information about enemy airborne targets. This asset could assist AWACS in building the air picture for counterair weapon systems.

Two sensors currently in development which hold the greatest promise in assisting with finding and identifying airborne targets are spectral sensors and bistatic radars. Spectral sensors use multiple bands of reflected radiance to provide unique detection, targeting, and identification capabilities. The greatest limitation of spectral imagery is the enormous amount of data, which must be transmitted over a data link.[3] This data must then be processed and the information integrated into current surveillance systems to build the air picture. The second sensor, bistatic radar, is an advanced surveillance concept where one UAV would employ a receive-only radar operating with existing radar systems such as AWACS. The bistatic platform could be flown closer to the threat area than current sensors and receive the radar pulses of the AWACS. The bistatic radar, given the close proximity to the threats, would have a higher signal-to-noise ratio over the long standoff range monostatic systems and thus could extend the range of detection into enemy territory.[4] Both of these sensors are in the testing phase with UAVs and their potential to fill the void is yet to be determined.

Electronic Attack

One payload functional area that is in advanced levels of development stage and will likely be an operational payload in the near future is electronic attack. The reason for this technological advancement is partly due to the aviation industry's successful integration of EA technologies into combat aircraft and their EA pods. For years, industry has worked to miniaturize and advance the technology needed for sophisticated EA hardware in combat aircraft. Now, several organizations are successfully integrating EA technologies into UAV payloads. It is highly possible the UAVs deployed in our next military endeavor will have some EA payload on board. One envisioned concept places EA UAVs in the same general proximity as the air superiority CAPs to provide the electronic warfare required to screen friendly air superiority fighters.

Northrop Grumman has a current solution for EA UAVs. Northrop Grumman has integrated its TRR, mentioned above, with a “Tactical Radar Jammer (TRJ)” to form a “Tactical Radar Electronic Combat System (TRECS).” This system is capable of finding, identifying, and electronically attacking radar emitters. “This jammer offers a variety of EA techniques, including range gate pull-off, velocity gate pull-off, and multiple false targets.”[5] Although small by aircraft standards, current payloads can only fit into the larger strategic UAVs. Nevertheless, advances in the EA field are yielding impressive results that can and are being integrated into UAV payloads.

Suppression of Enemy Air Defenses

Two lessons learned from the US involvement in the war in Kosovo have emerged. First, current US SEAD assets are overworked. Second, those assets have not been adequately developed.[6] While the US has not yet placed a miniature High-speed Anti-Radiation Missile (HARM) or bomb on a UAV, other technology exists that would help aircrews survive against air defense systems. The Naval Air Systems Command is working with Dedicated Electronic Inc. to develop a SEAD capability for UAVs. This SEAD payload will produce multiple false targets to enemy search and acquisition radars systems, which would cause enemy air defenses to target contacts that were not really there.[7] Systems such as TRECS will also assist in the SEAD mission. In addition to providing false targets, TRECS could jam the search and acquisition radars, thus denying the enemy the opportunity to shoot at friendly aircraft.

The future of UAVs and the SEAD mission will most likely be in the form of dedicated SEAD UCAVs. The current limiting factor for this concept is the miniaturization of weapons with the required destructive power. Much of the technology and its associated capability are beyond the classification and scope of this research paper. Ideally, though, one or more dedicated

SEAD UAVs would accompany counterair weapon systems into hostile territory to provide the additional SEAD protection necessary for combat operations.

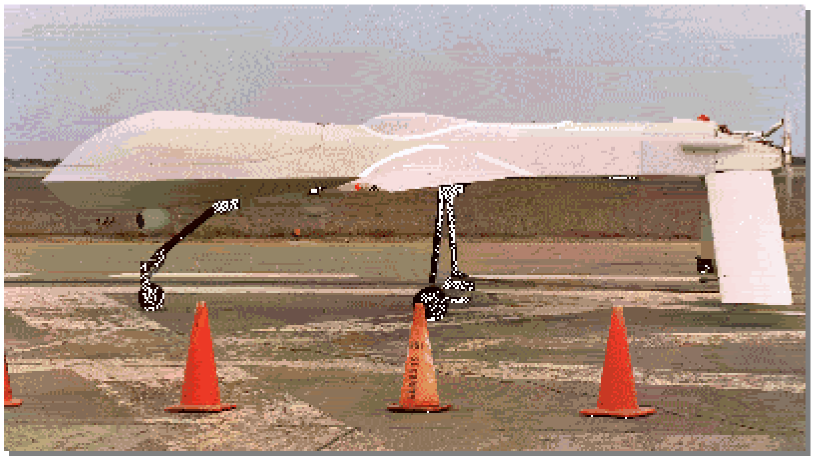

Figure 6. Predator

Training and Exercises

Before UAVS are employed in an augmenting role in combat operations, they must be integrated into large force exercises such as Green/Red Flag to validate the concept and train with the warfighters that they will operate with in combat. In order to best determine the proper UAV tactics, current classified tactics manuals (MCM 3-1) should be referenced. These manuals provide an excellent source of support asset integration information. The US currently integrates support assets very well into large force packages and the integration of UAVs should not significantly change current package composition. Air-to-air mission commanders and weapons officers are best suited to determine the exact employment mix of combat assets and associated tactics.

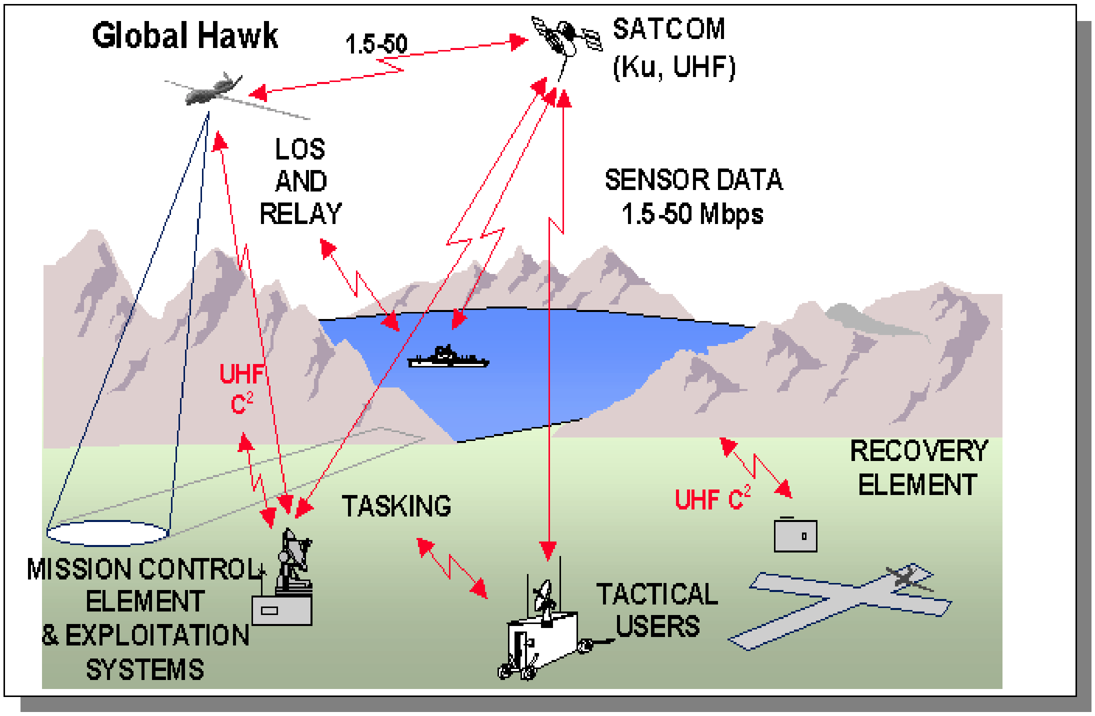

Figure 7. UAV Communications Integration

UAV Integration Hurdles

Two key issues for the integration of UAVs into combat operations of any mission are the communications interface of systems involved and redundant or overlap in payloads. The first issue involves obtaining the correct communication architecture and data links to integrate the UAVs. Figure 7 shows a typical communication diagram of a UAV in a theater of operation. In order to both control and interface with a UAV, a myriad of communication links are necessary.

Problems arise when UAVs attempt to communicate with counterair assets. Currently, AWACS and some counterair weapon systems are equipped with data link connectivity (Link-16), but are not integrated with the UAVs' data link. To overcome this hurdle, UAVs that will integrate into combat operations should be able to data link their data to AWACS. The E-3A would then act as a "hub" or central data processing point to filter and disseminate data to all the applicable weapon systems. Moreover, every counterair weapon system in DoD must possess the connectivity (Link-16) to receive this filtered information. This is currently an on-going endeavor.

The second issue for UAV integration deals with DoD acquiring the correct UAVs and payloads without redundantly spending time and money by the separate services. The Advanced Concept Technology Demonstration (ACTD) process is an effective means for the development of UAVs, but the true issue lies in DoD's Joint Staff before UAVs are sent through the ACTD process. The issue is focus—being able to prioritize at the highest level which systems are needed and then placing emphasis on acquiring those systems that are jointly employable.

Whether on the surface or in the air, every military operation first requires dominance in the air. Air superiority ensures the freedom from attack and the freedom to operate. For this reason, the function of counterair must be given priority in the development of UAVs. Moreover, as the executive agent in DoD for UAVs, the US Air Force should take the lead in guiding the development of future UAVs. A joint effort is required to ensure that not only the Air Force, but also every service's counterair assets will benefit from the proper integration of UAVs into this function. As other countries develop and deploy their UAVs, the US must stay well ahead of these countries to ensure that our dominance in the air remains unchallenged.

Operational Control of UAVs

The final issue for the successful integration of UAVs into the function of counterair deals with operational control of these assets once they are fielded. For UAVs with functions that support local missions, the local commander must possess operational control. Specifically, the Joint Force Air Component Commander (JFACC) exercises operational control of all the services aircraft that employ in the function of counterair (with the exception of some USMC aircraft). In order to successfully integrate UAVs into this function, UAVs must be placed under the control of the JFACC and integrated into the planning process. Moreover, all UAVs under JFACC control must be placed on the Air Tasking Order (ATO) to ensure deconfliction from other aircraft and missions. By placing UAVs on the ATO, the commanders can ensure that UAVs are less likely to be lost to friendly fire.

Conclusions

Miniaturized UAV technology, possessing the ability to successfully overcome the limitations in surveillance, electronic warfare, and SEAD weapon systems currently exists at various levels of development. It is vital that the Joint Staff and the Air Force work to procure this technology and the correct mix of aerial vehicles that will contribute to gaining and maintaining control of the air in a joint and combined environment. Effective and efficient integration of UAVs into the function of counterair must occur first in training exercises before successful combat operations can be accomplished. Once counterair UAVs are integrated into military operations, the JFACC must control the tactical employment of all aerospace assets involved in the campaign including UAVs. Counterair UAVs will contribute to a level of dominance over the enemy, which will ensure no credible enemy air opposition will survive. If the above-mentioned plan for integration occurs, UAVs will significantly assist military commanders in achieving their operational objectives while reducing the risks to aircrew members in combat.

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Part 5

Conclusions

> *We must perceive the necessity of every war being looked upon as a whole from the very outset, and that at the very first step forward the commander should have the end in view to which every line must converge.*
>
> —Carl Von Clausewitz

In order to achieve the National Command Authority's strategic objectives, the US must totally overwhelm its enemy in every aspect of an operation. Whether the next US military operation is a major theater war or a limited regional conflict, air superiority over the battlefield must first be achieved. Currently, the number of systems that contribute to achieving the function of counterair are not at the level of dominance desired to ensure quick success while limiting the loss of friendly life and resources. UAVs have significant potential to enhance the ability of US military counterair weapon systems. UAVs can play a major role in obtaining dominance over an enemy by filling the current gaps in the capabilities in US weapon systems.

By integrating UAVs into the function of counterair, other aerospace power functions will also benefit from counterair UAV capabilities. By employing UAVs to assist in building the air picture, strike and interdiction weapon systems will also gain valuable information necessary to successfully complete their missions. Likewise, tactical UAVs that perform EA and SEAD will provide redundant protection for every airframe that flies into enemy territory. Therefore, by integrating UAVs into counterair, all combat weapon systems will benefit either directly or indirectly, from the added capability that UAVs can be bring to the fight.

The question remains as to the best mix or allocation of UAVs and their payloads to provide the optimum results in combat. The answer, like most military answers, is—it depends. The physical size of the operation, the number of friendly resources involved, the number and capability of the enemy, and the type of missions required would determine what and how many UAVs should be dedicated to each phase of an operation. Organizations such as the US Air Force and Navy Test and Evaluation Squadrons and Weapons Schools possess the resident experts to best answer the questions of what and how many UAVs should be employed in combat operations. At a minimum, for operations such as ALLIED FORCE, at least one strategic UAV with a multiple payload capability, which can remain in position for long periods of time, should be employed to assist in building both the air and the ground pictures. For the functions of EA and SEAD, a tactical UAV should be employed in a position to augment current EA and SEAD aircraft that support counterair weapon systems. Likewise, if counterair assets are employing in an offensive counterair role, then tactical UAVs (one for each EA and one for SEAD) should penetrate enemy airspace at the correct time to provide the desired effects for the airborne packages involved.

Recommendations

There are four recommendations that should be implemented if the integration of UAVs into the function of counterair is to succeed. First, the USAF should assume the lead role for the DoD in programs to develop, exploit, and employ both strategic and tactical UAVs in order to integrate those UAVs in a joint and combined operation. The following recommendations parallel those made by the USAF Scientific Advisory Board Study. They include, but are not limited to, initiating additional programs to miniaturize and reduce costs of technologies for UAVs; improving techniques for flight management, airspace management, and employment of

UAVs; and promoting command, control, communications, and intelligence architectures that consider UAVs in context with the overall Joint Forces structure.[1] Additionally, the US should work closely with other leading countries deeply involved with UAV development (Israel and Australia) to foster technology transfers and ensure coalition systems compatibilities.

Second, the USAF should continue to research and develop strategic, medium and high altitude endurance UAVs (Predator and Global Hawk) that will assist in building the air and ground pictures. It is imperative that these strategic UAVs possess the capability to perform multiple functions to support multiple missions as a means to reduce overall program costs and ensure procurement. Two future fields of technology that hold great promise for strategic UAVs and should be further developed are spectral imaging and bistatic radars.

Third, the USAF should continue to research and develop tactical UAVs (Pioneer, Outrider, and future UAVs), which have the ability to swap out various payloads and can perform multiple functions to support multiple missions. The payloads that can be quickly developed for tactical UAVs include, but are not limited to electronic warfare and suppression of enemy air defenses. Additionally, further research is essential in the field of miniaturized weapons for unmanned combat aerial vehicles.

Lastly, once the above recommendations are accomplished, then the USAF should actively integrate these UAVs into its Expeditionary Air Forces (EAF) concept. It is critical that UAVs be incorporated into current operational war plans (OPLANS) and Time-Phased Force Deployment Data (TPFDD), which state what types of units will deploy to a particular theater and when. Moreover, these UAVs should be integrated into various training exercises such as Red/Green Flag so that counterair weapon systems may practice with all the assets that they will employ with in combat. The axiom “train the way you intend to fight” has been repeatedly proven true and should also be applied to UAV integration.

In closing, the integration of UAVs into the function of counterair is not only technologically feasible, but also absolutely essential for the future success of the US military in combat operations. It is critical as more countries delve into UAV employment that the US remains at the forefront of UAV research and development. As the DoD continues to draw down its forces, UAVs will significantly enhance the US military’s ability to remain the dominant force in combat. Without UAVs, military commanders and strategic planners may find it difficult to execute military strategy in support of strategic national and coalition objectives.

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Glossary

ACSC	Air Command and Staff College
ACTD	Advanced Concept Technology Demonstration
ARITA	Airborne Reconnaissance Information Architecture
ATO	Air Tasking Order
AU	Air University
AWACS	Airborne Warning and Control System
BVR	Beyond Visual Range
CIA	Central Intelligence Agency
DoD	Department of Defense
EA	Electronic Attack
EAF	Expeditionary Air Forces
EO	Electro-Optic
HARM	High-Speed Anti-Radiation Missile
IMINT	Imagery Intelligence
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
JFACC	Joint Force Air Component Commander
LOS	Line of Sight
MASINT	Measurement and Signatures Intelligence
MRC	Major Regional Conflict
NATO	North Atlantic Treaty Organization
OPLAN	Operational war plan
SAF	Secretary of the Air Force
SAM	Surface-to-air Missile
SATCOM	Satellite Communications
SEAD	Suppression of Enemy Air Defenses
SIGINT	Signals Intelligence
TPFDD	Time-Phased Force Deployment Data
TRECS	Tactical Radar Electronic Combat System
TRJ	Tactical Radar Jammer
TRR	Tactical Radar Receiver
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Aerial Vehicle
UHF	Ultra High Frequency
US	United States
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy

Definitions

Air superiority: That degree of dominance that permits friendly land, sea, and air forces to operate at a given time and place without prohibitive interference by the opposing force.

Counterair: The primary function used in gaining and maintaining air superiority and consists of offensive and defensive operations to destroy or neutralize enemy air and missile forces. Counterair is directed at enemy forces and target sets that directly (airborne aircraft, surface-to-air missiles, etc.) or indirectly (airfields; petroleum, oil, and lubricants; production facilities; etc) challenge control of the air.

Global attack: The ability of the Air Force to attack rapidly and persistently with a wide range of munitions anywhere on the globe at any given time is unique.

Information superiority: The ability to collect, control, exploit, and defend information while denying an adversary the ability to do the same and, like air superiority, includes gaining control over the information realm and fully exploiting military information functions.

Unmanned Aerial Vehicle: A powered. Aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload.

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